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LOS ALAMOS SCIENTIFIC LABORATORY
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IN REPLY
REFER TO: H

March 2, 1972

Please put in
Palomares
Ramos
Spanish file

H. D. Bruner, M.D.
U.S. Atomic Energy Commission
Division of Biology and Medicine
Washington, D.C. 20545

Dear Dave:

Enclosed is a copy of my trip report to Copenhagen and Spain. I hope you find it both interesting and informative. You might show it to John Totter since he wrote an official letter to Agnew pointing out that I was delinquent in filing a report of my foreign travel.

Sincerely yours,

Wright H. Langham

WHL:bd

Enclosure as stated

01619

LOS ALAMOS SCIENTIFIC LABORATORY
UNIVERSITY OF CALIFORNIA
LOS ALAMOS, NEW MEXICO 87544

OFFICE MEMORANDUM

TO : P. F. Belcher - ADSL

DATE: March 1, 1972

FROM : W. H. Langham

SUBJECT: TRIP REPORT ON FOREIGN TRAVEL (OCTOBER 25-NOVEMBER 15, 1971)

SYMBOL : H-DO

Current concern over environmental plutonium contamination generally and contamination of the environs of the Nevada Test Site specifically prompted a trip to Copenhagen, Denmark, and to Palomares, Spain (via Madrid), to hear first-hand from the people primarily involved the sequel to the nuclear weapons accidents at Thule, Greenland (1968), and at Palomares, Spain (1966). These two incidents attracted international attention because they involved plutonium contamination of the public domain of foreign countries. A brief account of these incidents is given for those who may have forgotten or those who may not be familiar with them -- although it is difficult to imagine either situation.

THULE, GREENLAND

The Thule Incident

The Thule incident occurred on January 21, 1968. A crew-abandoned SAC B-52 bomber carrying four nuclear weapons crashed on the ice of North Star Bay approximately seven miles from the west end of the Thule runway. The aircraft and nuclear weapons disintegrated on impact, and the plutonium-239 inventory of all four weapons was released to the environment. About 3200 g

of plutonium, largely in the form of plutonium oxide particles, was trapped in the fire-blackened area of melted and refrozen snowpack about 500 feet wide and 2100 feet long. About 350 g of plutonium was trapped in the crushed and refrozen ice at the impact point, and the remainder was impinged into the aircraft wreckage, blown beneath the ice, and dispersed as airborne contamination in a predominantly southerly direction from the crash site. It was not possible to say how much of the plutonium was deposited as general airborne environmental contamination, but it could not have been more than a few kilograms. Cleanup of the Thule incident consisted of collection of all parts of the weapons and parts of the aircraft (not blown beneath the ice at point of impact) and removal of the blackened, refrozen snowpack down to the original surface ice. All collected material was returned to the continental United States. The ice (3 to 4 feet thick) at the point of impact was completely broken into chunks that were displaced downward into the water. These pieces floated back to the surface and were fixed in a random orientation by refreezing. Extensive ice core sampling allowed the estimation that about 350 g of plutonium was contained in the ice at impact point. This area, that would have been very difficult to remove, was covered with black, carbonized sand. Heat absorption after the sun began to shine resulted in early melting of the area before general break-up of the bay ice occurred. Therefore, at least 350 g of plutonium plus that blown beneath the ice at time of impact was released to the waters of North Star Bay. During subsequent months Danish scientists, with U. S. help, conducted an extensive ecological survey and again in 1969 and 1970. The purpose of the trip to Copenhagen was to hear first-hand the general results and impressions gained from these follow-up studies.

Thule Results

It was with great sadness that I learned of the death from cancer of Professor Jorgen Koch, a personal friend and head of the Danish scientific team in 1968, only a month prior to my arrival. Because of Professor Koch's death, my visits were confined largely to his widow; Dr. Henry Gjørup (a member of the 1968 Danish scientific team), Head of the Health Physics Department, Danish Atomic Energy Research Establishment, Riso; and Mr. Per Grande, Director of the Danish National Health Service, State Institute of Radiation Hygiene (also a member of the 1968 Danish scientific team).

The first year an extensive ecological sampling program of the Thule area flora and fauna was conducted, and samples were sent to Riso for plutonium analysis. Their conclusions were that the accident measurably raised the plutonium level in the marine environment as far out as approximately 20 kilometers from the point of impact. The highest concentrations were found in bottom sediment, bivalves, and crustacea. The higher animals such as birds, seals, and walrus showed plutonium levels hardly significantly different from the fallout background. Stomach contents of the higher animals were analyzed both with respect to the biota ingested and their plutonium content. Ingesta contained many of the lower life forms that concentrate plutonium; however, plutonium levels were hardly above regional background, indicating that the animals sampled had not been feeding in the higher contamination areas. In principle, analysis of ingesta is an effective method of sampling a contaminated environment in relation to specific species at risk. Fistulated cattle and goats (one a grazing species, the other a browser) would be effective samplers of certain contaminated areas in and near the Nevada Test Site. Plans to conduct such studies are in the formative stages and should be considered as a high-priority activity.

In subsequent years the sampling program at Thule has been confined largely to bottom sediments and the bivalves and crustacea brought up in the sediment sampling. The levels in bivalves and crustacea are comparable to that in the sediments in which they live, and a major part of the activity is confined to external surfaces. Activity of the sediment appears to be spreading out and decreasing exponentially with time. Their continued interest seems to be in using the sediment sampling program to collect useful information on currents and sediment movements in Bylot Sound and on early incorporation of plutonium into a relatively simple food web. They plan to return to Thule during the open period in 1972. Dr. Gjørup informed me that more participation of U. S. scientists would be welcome.

An unrelated but side issue of considerable interest was revealed by a visit to the State Institute of Radiation Hygiene. Mr. Per Grande's Institute does all radiation hygiene surveillance (except for Riso) for the whole of Denmark with a very modest staff (about 20). Their primary record of exposure is the film badge, which the Institute processes, reads, records, and files. The developed film is matched by eye with a set of standards. Only those showing a density greater than that corresponding to 10 mrem per week are densitometered and recorded. There seems to be little or no public agitation about the horrors of radiation. Either the Danish public is immune to the radiation hysteria virus, or it has not spread to that part of the world. They are now earnestly talking about developing nuclear power stations; perhaps introduction of the virus will be forthcoming.

MADRID AND PALOMARES

The Palomares Incident

On January 17, 1966, a B-52 refueling accident occurred above the Spanish village of Palomares (population about 1000) on the Spanish Mediterranean coast. Both the bomber and KC-135 tanker were destroyed in the air. One of the four nuclear weapons aboard the bomber was recovered intact from the Mediterranean about five miles off-shore, and a second was recovered intact from the dry Almanzora riverbed east of the village (impact point No. 1). The main chutes did not open on the other two, and on impact they underwent high explosive detonation, one in the east edge of the village (impact point No. 3) and the other approximately one mile to the west (impact point No. 2). At the time a 30-knot wind was blowing toward the east. The plutonium-bearing dust cloud from the one toward the west traveled across irrigated fields and the northern edge of the village. The cloud from the one that fell in the eastern edge of the village traveled away from the village but across the prime irrigated areas for growing tomatoes, beans, and alfalfa. The last tomato crop of the season was just ready for harvest. Corrective measures consisted of removal and shipment back to the U. S. of the vegetation and topsoil from approximately 5.4 acres where the surface contamination was above 32 $\mu Ci/M^2$ and removal of vegetation and plowing of all accessible areas with surface contamination between 32 $\mu Ci/M^2$ and the lower limit of detection of the portable alpha monitoring instruments in use at the time (less than 0.32 $\mu Ci/M^2$). The total area plowed was approximately 550 acres. The cloud from the detonation west of the village traveled down a small valley, the upper end of which had once been in dry-land farming but long abondoned because of inadequate rainfall.

The lower end of the valley near the village was under irrigation. The principal crops here were tomatoes and alfalfa. Because of the rough, rocky terrain, it was not practical to plow the sides of the valley even though contamination levels in spots were greater than 3.2 $\mu Ci/M^2$. In this case attempts were made to work into the ground with pick and shovel all "hot spots" that were greater than this value. Hillside contamination less than that was left untreated except for picking up contaminated aircraft debris.

Palomares Results

An agreement between the U. S. and Spanish Atomic Energy Commission set up a four-point follow-up program to the Palomares incident. The program was to be strictly under the direction of the Junta de Energia Nuclear's Division de Medicine y Proteccion (Dr. Eduardo Ramos) with equipment, technical help, and operational support from the U. S. Atomic Energy Commission. The four-point program was as follows:

(1) Collection of information on uptake and retention of plutonium and uranium by representative numbers of a population group potentially exposed to inhalation of a plutonium oxide aerosol.

(2) Measurement of temporal and seasonal fluctuations in plutonium air concentrations above a plutonium oxide-contaminated agricultural area that has been subjected to the agreed upon decontamination procedures.

(3) Serial measurements of contamination levels (both by plant uptake from the soil and wind dispersal) of agricultural products produced in a contaminated area subsequent to decontamination.

(4) Studies of the temporal migration and redistribution of plutonium

oxide in soil, decontaminated by deep plowing, as a result of continued cultivation and weathering.

Technical assistance, approximately $250,000 in equipment (including whole-body and lung counter), and annual operating funds to the extent of about $25,000 per year, have been provided by the U. S. Atomic Energy Commission to support the effort.

Six or so unclassified papers have been prepared relative to the Palomares incident. These are largely general in scope and difficult to find. My records show the following articles, some of which I have copies:

(1) William D. Moss: Report on Bioassay Laboratory in Madrid, Spain, Los Alamos Scientific Laboratory Report H5MR66-1 (September 1966).

(2) Eduardo Ramos Rodriguez: Palomares Two Years After, presentation at some European conference, publication not known.

(3) Emelio Iranzo: First Results from the Programme of Action following the Palomares Accident, Symposium on Radiological Protection of the Public in a Nuclear Disaster (IRPA), Interlaken, Switzerland (June 1968).

(4) E. Iranzo and E. Ramos: Measures to Determine the Risk to which a Population can be Subjected as a Result of a Nuclear Accident Generating Radioactive Aerosols: Environmental Contamination by Radioactive Materials, International Atomic Energy Agency, Vienna, Austria (1969).

(5) C. Alvarez-Ramis and Gregorides de los Santos: Contamination de Gasteropodes Terresteres Habitat un Biotope a bas Niveau de Contamination Alpha Due Plutonium et a l'Uranium, Actes du Symposium International de Radioecologie, Centre d'Etudes Nucleaires de Cadarache du 8 au 12 (September 1969).

(6) Emelio Iranzo and Sinesio Salvador: Inhalation Risks to People

Living near a Contaminated Area, Second International Congress of the International Radiation Protection Association, Brighton, England (May 1970); not published.

In addition, uncirculated progress summaries of Palomares activities were prepared by Eduardo Ramos of the JEN Division de Medicine y Proteccion in April 1967 and November 1969.

In Madrid, I was privileged to see all primary data collected to date relevant to the four-point program. Under point one, 100 of the most likely exposed residents of Palomares were taken to Madrid and counted in the lung counter. The lower limit of detection of the counter was approximately 40 nCi. No positive counts were observed in any of the 100 individuals. The counter was modified by the Spanish to give a minimum detectable limit of about 16 nCi, and a few of the most likely exposed individuals were recounted. Even with the improved sensitivity, no positive counts were observed. Urine samples (24-hour) were collected from the same 100 individuals. Seventy-one percent of the subjects showed no indication of plutonium in the urine. The others showed urine values of less than 0.1 to 0.2 disintegrations per minute per 24-hour sample -- not statistically significant. It is my understanding that no further measurements have been made on the Palomares residents.

Point two of the agreement (measurement of air concentrations) was initiated with installation of four continuous air-monitoring stations and two meteorological stations strategically located with respect to the contaminated area. One of the air-monitoring and meteorological stations was located in the center of the village. Continuous air monitoring at all four stations were continued for approximately two years. Daily samples were counted for gross alpha activity,

and 10-day samples were pooled and analyzed for plutonium using chemical separation and alpha spectrometry. Uranium-234 and uranium-235 were determined also in the 1967 air samples. These results were reported in the paper by Iranzo and Salvador (paper No. 6 in the previous listing) at the Brighton International Congress.

Positive air samples were obtained occasionally at all stations, with the highest values coinciding with periods of high wind velocity (above 35 km/hour). Mean plutonium values in the village for 1966 and 1967 were 0.38 x 10^{-15} and 0.09 x 10^{-15} $\mu Ci/cm^3$, respectively. Only the air sampling station in the center of the village (station P) and the one in the irrigated fields to the east (station 3-2) are currently in operation. The others have been discontinued and salvaged to obtain parts to keep the other two in operation. Judging from sound, they are about ready to go also. In my opinion, it is unfortunate that station 2-2, strategically located to sample wind pickup from the untreated hillsides, has been discontinued.

With regard to point three of the agreement (plutonium in vegetation), periodic sampling has been conducted. Reported measurements to date are in terms of gross alpha activity. They now have alpha spectrometry data on most of the vegetation samples. The Palomares area is perhaps one of the highest natural alpha background areas in Spain. The number of samples to be processed is large, and the Spanish were given only one alpha spectrometer which has given poor service. Counting times for spectral measurements are long, and air samples alone have been taking most of the available instrument time. Alpha spectrometry analysis of all samples (air, vegetation, and soil) will be required before the actual plutonium contamination can be established. The

gross alpha and plutonium measurements of vegetation are characterized by great variability from area-to-area and from sample-to-sample within the same area. Undoubtedly, this variability is a manifestation of the difficulty of representative sampling and the nonuniform particulate nature of the environmental contamination. Contamination of vegetation appears to be almost entirely surface-deposited. Leaves and stalks run higher than the plant fruit. This is especially true for tomatoes. In general, natural vegetation runs much higher than cropped vegetation. Natural vegetation is usually confined to the hillsides, where plowing under of the plutonium was not practical and many of the plants are perennials. In 1969 and 1970, esparto grass (near impact point No. 2, area 2-1) ran 9063 and 10,314 pCi/kg of plutonium wet weight, respectively. Esparto is a tough perennial that grows from a crown of dead growth from past seasons. The crown appears to be an excellent filter for trapping moving particles. Artemisa from the same area ran 3861 pCi/kg. In 1969 alfalfa from area 5-2 ran 41 μCi/kg. Vegetation from the western side of the village usually runs higher than the same vegetation from areas in and east of the village. When alpha spectrometry data are complete, a summary of the vegetation analyses may show some interesting correlations with the levels and methods of cleanup. The article by Alvarez-Ramos and Santos (No. 5 of the previous list) gives considerable data on gross alpha activity of vegetation in the Palomares area during 1967 and 1968. Work has been done on gross alpha activity of snails, etc. (gasteropodes) from the area. Activities were very low. Fish samples from Garrucha, a fishing village near Palomares, showed no measurable activity.

The soil studies program (point four of the agreement) is a slow, arduous task fraught with many difficulties, the greatest being the representative

sampling problems. Analytical variations among samples are quite high. Six sampling plots, strategically located through the contaminated area, were laid out by Dr. Eric Fowler of Los Alamos. These are sampled annually in depth increments of 0-5, 5-15, 15-25, 25-35, and 35-45 cm. Surface samples are taken at several points in each plot. The vegetation samples are taken also from or near these plots. So far, the soil analyses are as gross alpha activity per gram. Alpha spectrometry analysis of the samples is just beginning.

In general, the relative depth distribution of activity is about as one would expect from the plowing operation. It is doubtful that one will see any significant redistribution with time because of inherent large statistical variations and low rainfall. One time variation that concerns the investigators has been noticed. The surface layer of the plowed areas near the hillsides that could not be plowed is increasing in activity with time. This is interpreted as resulting from movement and redeposition of plutonium from the hillsides and shows that plutonium deposited on the surface is indeed moving with the winds.

Return to Palomares

Southern Spain was visited by rental car, and one day and a night were spent in Palomares. Palomares is located in about the middle of the Costa Blanca, the least developed region of the Spanish Mediterranean coast. Both Dr. Ramos and Dr. Iranzo flew down to conduct the tour of Palomares. The most impressive observation was that of sameness. To me, Palomares looked exactly as it did immediately after the accident almost six years ago. A few things were different, however, when pointed out by our Spanish hosts. Beautiful

tomatoes still grow in Palomares; however, the area affected by the plowing operation is now used largely for growing barley and artichokes. It is not that tomatoes will not grow but, rather, that the accident and following two or three years of drought changed the farming habits of those affected. Barley grew better during the drought, makes almost as much income, and is less work than tomatoes. I do not recall seeing artichokes in the area before. The bomb impact point in the east edge of the village (impact point No. 3) is now the site of a sizable, rather modern hog house. The concrete wall installed to replace the rock wall destroyed by the bomb appears to be a part of the foundation of the new facility. Dry-land farming of the upper end of the valley west of the village (impact point No. 2) has not been resumed. The native ecology of this area was destroyed by the soil removal and plowing operation, and the native vegetation is gallantly struggling to return with some signs of reestablishment. Another casual observation was that one could see no signs of plutonium or its effects, but the effects of the plutonium clean-up operations were still in evidence. This is a point that might be worth keeping in mind with regard to clean-up activities contemplated at the Nevada Test Site. In my opinion, destruction of the slow-growing desert ecology of this area without some effort to establish the real necessity for doing so will be little short of criminal. It seems that some environmentalists are so bent on damning the Establishment that they forget the slogans on their banners.

General Comments and Impressions

(1) Drs. Ramos and Iranzo were pressured and questioned about publication and wider distribution of their data and observations. They showed me

manuscript material and tabulated data in various stages of preparation for publication as a special issue of the Junta de Energia Nucleaire's Journal, Energia Nuclear, an impressive, slick-paper bimonthly publication. The articles will cover the following subject matter: (a) bomb physics and phenomenology (Pasqual); (b) general description of the accident (Ramos); (c) physiology and toxicology of plutonium (Ramos); (d) plutonium in soils (Iranzo); (e) plutonium in vegetation (Iranzo); (f) plutonium in air (Iranzo); and (g) summary. They are hoping for publication of the special issue by mid-1972. However, they do not work fast, and their very limited staff seems overcommitted because of pressures of other problems. Dr. Iranzo particularly seemed disturbed about rushing publication when much of the desired alpha spectrometry data are incomplete. I share his concern but feel that they should go ahead as fast as possible with publication.

(2) Some of their equipment is now obsolete and their facilities still poor by U. S. standards. The equipment we gave them is now six years old. It has not been updated, improved, or added to.

(3) To me, enthusiasm for the work did not seem as high as it once was. This could be a result of their having to turn their attention during the last year to a fission-product release into a major river used for irrigation of vegetable crops for the Madrid market. It could be also that we have not maintained the interest and attention in the Palomares program manifested originally. I promised that I would return to see them in a year or so. I did not return for almost six years -- my excuse, limited foreign travel funds.

(4) They are understaffed technically and depend a lot on use of graduate students supported by the $25,000 per year operational support from the U. S. Atomic Energy Commission.

Current concern in this country over plutonium environmental contamination from the breeder reactor developmental program and from projected uses of plutonium-238 might justify considering revitalization of the Palomares program. One might consider the following actions:

(a) Encourage them to get on with publication of their observations to date.

(b) Increase operational support to provide more technical staff.

(c) Update their equipment and certainly provide at least one additional alpha spectrometer.

(d) Reevaluate their approaches to the four points of the agreement and modify them as indicated by the past six years of experience and the accumulated data.

(e) Consider the advisability of providing them with a new lung counter to recount a number of the 100 Palomares residents examined the first year after the accident. Counters are now possible with a minimum detectable limit of 4 ± 4 nCi of plutonium; their sensitivity to americium-241 is 100 times greater. Results on people who have lived in a contaminated area for 6 years after an accident might be of value even if all negative -- as I am relatively certain they would be.

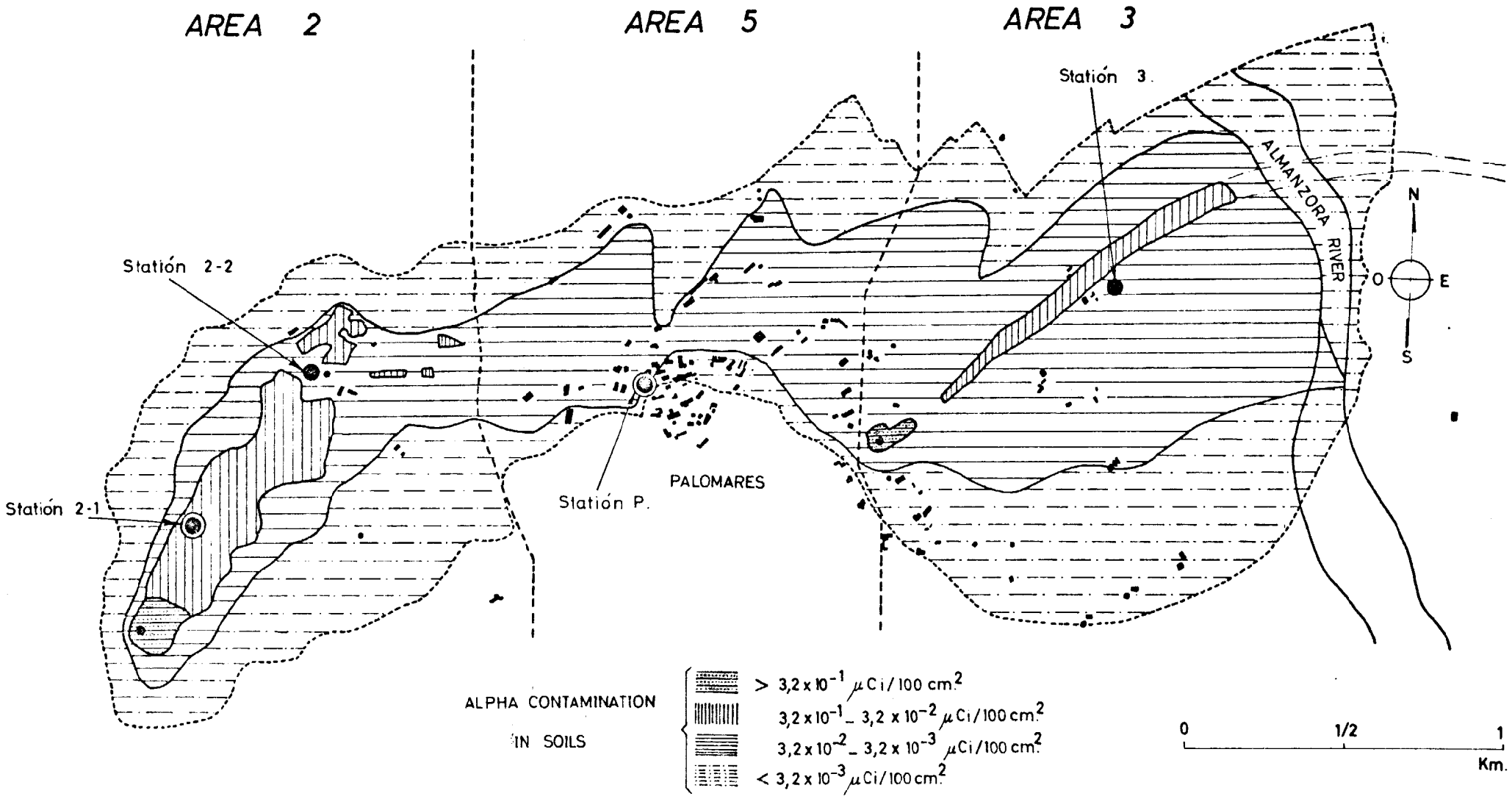
(f) Manifest more interest in their work through more review of their efforts.

I cannot resist one more casual comment. Tourism has become Spain's largest industry. Last year they had 25 million tourists, while the total population of Spain is only about 35 million. During the 1966 negotiations with high Spanish officials, their great concern was that the nuclear weapon

accident and residual plutonium would interfere with promotion of tourism in this region of the Costa Blanca -- as was occurring throughout the Costa Brava and Costa del Sol. The latter regions of the Spanish Mediterranean coast now look like Miami Beach crowded with high-rise apartments and luxury tourist hotels. The idea that the bleak, isolated region around Palomares and Mojacar would ever be developed for tourism seemed so incongruous at the time that it was my opinion they were using the issue only for bargaining purposes.

During the return visit to Palomares, I stayed in the government-owned Parador Motor Hotel (only 12 miles from where the bombs fell) with dining room, bar, and rooms with a balcony and picture windows overlooking the Mediterranean. Only five miles from the Parador in Mojacar (a glistening white Moorish village on a mountain top, steeped in history back to 2000 B.C. and the birth place of Walt Disney) is a fabulous luxury hotel designed by a Madrid architect. The architect, Roberto Puig, saw from the window of his apartment in Mojacar the explosion that released the bombs over Palomares. He claimed to have rushed to Palomares and sustained a radiation burn to his knee while inspecting one of the bombs in its crater. He became very concerned that he had been contaminated by plutonium and injured by radiation. The JEN Division de Medicine y Proteccion, after much counciling and examination, was able to allay his fears, and he completed his designs of the Hotel Mojacar. Perhaps someday Roberto Puig, his fabulous hotel, and the nuclear weapons accident over Palomares will become just another of the many legends to tell visitors to the ancient and spectacular village of Mojacar on the Costa Blanca. However, the question now is: will continuation and revitalization of the studies of plutonium contamination of the area, now almost forgotten, be both desirable and worthwhile?

Figura 1.


AREA 2
AREA 5
AREA 3
Station 3
ALMANZORA RIVER
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Station 2-2
Station 2-1
Station P.
PALOMARES
ALPHA CONTAMINATION
IN SOILS
> 3,2 x 10⁻¹ μCi/100 cm²
3,2 x 10⁻¹ _ 3,2 x 10⁻² μCi/100 cm²
3,2 x 10⁻² _ 3,2 x 10⁻³ μCi/100 cm²
< 3,2 x 10⁻³ μCi/100 cm²
AIR SAMPLING AND METEOROLOGICAL STATION.
0
1/2
1
Km.